



US Army Corps
of Engineers

Hydrologic Engineering Center

1998 Annual Report

R_{esearch}

T_{echnical Assistance}

T_{raining}

Annual Report

TABLE OF CONTENTS

Director's Comments	Page 1
Administration and Funds	Page 3
Research and Development	Page 7
Hydrologic Engineering Research Program	Page 8
Risk Analysis of Water Resources Investments Research Program	Page 14
Geospatial Information Systems Research Program	Page 15
Water Control Data System Modernization	Page 16
Mississippi Basin Model System (MBMS)	Page 23
Hydrologic Engineering Guidance Program	Page 23
Training & Technology Transfer	Page 24
Technical Assistance Projects	Page 30
Acknowledgments	Page 34

Director's Comments

Top priorities for FY 1998 were our NexGen software research and development project, the Water Control Data System (WCDS) modernization corporate software development and integration project, watershed and water resource system analysis, and large-scale flood frequency studies. Progress was substantial in all these areas. Customer demand for HEC services and products continues to be high. Several large reimbursable projects resulted in HEC fiscal status at year at an all-time high. The professional staff remained stable with minor turnover.

The NexGen software research and development project continues at a brisk pace. The project is developing and fielding software tools to help Corps professionals perform their work better, more efficiently, and with increased ease. We now have released to field offices and the public, maiden release of the River Analysis

*THE NEXGEN
SOFTWARE
RESEARCH AND
DEVELOPMENT
PROJECT
CONTINUES AT A
BRISK PACE.*

System - HEC-RAS, followed by several major updates, the latest Version 2.2 is the final steady flow version; maiden Version 1.0 of the Hydrologic Modeling System - HEC-HMS; and maiden Version 1.0 of the Flood Damage Analysis package - HEC-FDA. Work has now begun in earnest on expanding HEC-RAS for unsteady flow; the first release is planned for the end of FY 1999. An updated release of HEC-HMS is planned for FY 1999 that will include enhancements to the spatial precipitation and runoff modeling capability, continuous soil moisture accounting, and release of a snow melt adjunct software capability under development in cooperation with the Cold Regions Research and Engineering Laboratory.

The HEC-FDA is undergoing improvement with a new release planned for FY 1999. New statistical uncertainty analysis, improved data base operations, GIS capability, and a number of enhanced user features will be additions for the new release. A beta version of a new reservoir operation program emphasizing real-time decision support was completed and is included in the suite of WCDS software.

A focused project to modernize the Water Control Data System (WCDS) software began in FY 1997. WCDS is the Corps decision support Automated Information Systems (AIS) that serves the Corps water management mission. It embodies data acquisition, manipulation and management; forecasting, simulation and decision support analysis; and information dissemination. Modernizing the corporate software for WCDS is a five year, five million dollar centrally PRIP funded, Corps AIS improvement project managed under the Corps Life Cycle management of Information Systems (LCMIS) process. The management structure and design teams form a unique arrangement for providing oversight and field participation in the enterprise-wide development and integration project. A significant accomplishment in FY 1998 includes completion of a fully functional but limited capability version 1.0 prototype incorporating aspects of all eight components comprising the modernized WCDS. The prototype and other project documents are available on the project Web site (<http://cw71.cw-wc.usace.army.mil/cwcinfo/cwc.html>). Planning was accomplished for deployment of Version 1.0 early in FY 1999 at four selected field office sites.

*A SIGNIFICANT
ACCOMPLISHMENT IN FY
1998 INCLUDES
COMPLETION OF A FULLY
FUNCTIONAL BUT LIMITED
CAPABILITY VERSION 1.0
PROTOTYPE...*

Work supporting implementation of risk-based analysis for flood damage reduction studies continued at a steady but reduced pace this past year. In the previous six years, eleven PROSPECT courses, fifteen on-site workshops and a number of executive and field project working sessions were held for a total of about 1250 Corps professionals. PROSPECT courses will continue at about one per year in risk-based analysis. HEC-FDA, the new software package written to support this initiative, is now in widespread use by Corps offices. A lessons-learned seminar was held the first quarter of FY 1998; proceedings have been published. Risk-based analysis

for flood damage reduction studies is now routinely applied by the Corps. A National Academy of Sciences panel is scheduled to review the Corps use of risk-based analysis beginning in early FY 1999 and HEC will be supporting that activity.

THIS CONTINUED THE
RECENT TREND OF
REDUCED PROSPECT SIGN-
UPS AND INCREASED
REQUESTS FOR ON-SITE
WORKSHOPS.

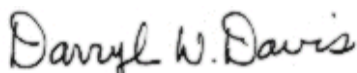
Six PROSPECT courses were conducted for a total of six weeks of training. The courses covered several hydrologic engineering and planning analysis topics. Attendance averaged about 25 students per course. Twelve on-site workshops were also held totaling seven weeks of sessions for 325 students. This continued the recent trend of reduced PROSPECT sign-ups and increased requests for on-site workshops. Topics presented included WCDS real-time working sessions, HEC-RAS, HEC-HMS, risk-based analysis, and reservoir operations/HEC-5.

Reimbursable project work was undertaken for 19 Corps field offices as well as HQUSACE, the Institute for Water Resources, Cold Regions Research and Engineering Laboratory, the Federal Emergency Management Agency, Federal Regulatory Commission, National Institute for Building Sciences, a combine of the State of California and Metropolitan Water District of Southern California, and the University of California, Davis. Projects include watershed and reservoir system modeling, water quality, risk-based analysis, river hydraulics, wetlands hydrology, water control management, regional statistical analysis, flood damage analysis, and groundwater modeling. We continued the several years of commitment to the Alabama-Coosa-Tallapoosa, Apalachicola-Chattahoochee-Flint (ACT/ACF) surface water and water quality modeling projects. A critical achievement was the signing of an Interstate Compact by the parties, based in-part on the modeling studies.

Several high profile flood frequency studies are being supported; on the American River in California, the Des Moines River in Iowa, and the upper Mississippi River. The Bulletin 17B (Federal guidelines for flood frequency) work group and a cadre of university and industry experts are serving as technical advisors to the upper Mississippi flood frequencies project under HEC management. Two major water resource system analysis projects were begun late in the year: data compilation and simulation and optimization models for the Sacramento/San Joaquin rivers flood control systems; and data management and simulation and optimization models for the Panama Canal Expansion study. The total reimbursable program was about \$1.7 million with individual projects ranging from a few thousand dollars to over \$300 thousand.

We expect the HEC program for FY 1999 will continue FY 1998 efforts at the increased pace reflected at the end of the year. We will continue fielding new versions of the NexGen software packages HEC-RAS, HEC-HMS, and HEC-FDA, test version of the new reservoir simulation program, and initial unsteady flow capability of HEC-RAS. Version 1.0 of the modernized WCDS will be fielded in four Corps offices. PROSPECT training will remain at about six courses and field workshops will likely continue to increase. Research and Development funding is expected to modestly increase, software maintenance and support and WCDS modernization funding remain at FY 1998 levels, and reimbursable technical assistance and special projects continue the upward trend. On balance, the result is expected to be an increase in funding over that of 1998. The reorganization that was expected to impact HEC mentioned in the FY 1997 Annual Report has not yet occurred. Our status is still uncertain, but we are continuing our activities without negative impact, and do not expect to be adversely affected when the change eventually occurs.

WE EXPECT THE HEC
PROGRAM FOR FY 1999
WILL CONTINUE FY 1998
EFFORTS AT THE
INCREASED PACE...



Darryl W. Davis, P.E.
Director

Administration and Funds

Responsibilities

The Hydrologic Engineering Center was established in 1964 to provide applied research, training, and technical assistance in hydrologic engineering to Corps field offices. In 1971, responsibilities were expanded to include planning analysis. Current activities now address a wide range of hydrologic engineering and planning analysis concerns.

The annual program is based on: (1) program direction from the HQUSACE Civil Works Directorate (Planning Division and Hydraulics and Hydrology Branch, Engineering Division) and the Corps Research and Development Directorate; (2) requests for assistance from Corps district and division offices; (3) cooperative work with Corps research laboratories; and (4) cooperative work with other government and professional organizations. Program activities are coordinated on a continuing basis with HQUSACE proponents and the Corps' user community.

HEC is an element of the Water Resources Support Center headquartered in Alexandria, Virginia. The Water Resources Support Center provides Corps-wide water resources support services for the Directorate of Civil Works, Headquarters, US Army Corps of Engineers (HQUSACE). HEC has been granted authority, within the approved program, to deal directly with Corps offices and others.

Goals of the Hydrologic Engineering Center

The primary goal of HEC is to support the Corps in its water resources management responsibilities. This is accomplished by increasing the Corps technical capability in hydrologic engineering and water resources planning and management and providing leadership in improving the state-of-the-art in hydrologic engineering and water resources planning.

By means of programs in research, training, and technical assistance, HEC maintains awareness of the problems and needs of the Corps and the nation. A commitment is also made to keep abreast of the latest developments throughout the profession, and to make use of this information in a manner best suited to the needs of the Corps.

HEC increases the effectiveness of the Corps and the profession by bridging the gap between the academic community, practicing hydrologic engineers, and planning professionals. Research and training activities that can be best accomplished by universities are not undertaken. HEC incorporates state-of-the-art procedures and techniques into manuals and comprehensive computer programs. The resulting products are made available to the Corps, and to other United States and international professionals through an effective technology transfer system of technical assistance, publications, video tapes, and training courses.

Research supplements relevant research at universities, private industry and other agencies. It develops systematic procedures that produce a quality product, it also saves time for experienced specialists and enables less-experienced personnel to use procedures effectively.

Training develops the Corps workforce and reduces the time necessary for young engineers and planning professionals to become proficient in technical analysis. It also familiarizes more experienced professionals with new methods.

Technical Assistance provides advice and assistance to Corps field personnel in the application of new or unfamiliar procedures to solve complex, precedent-setting water resources problems.

Administrative Services

Finance and accounting, contracting, supply, real estate, counsel, logistics and reproduction services are provided by reimbursable agreement with the Sacramento District (CESPK). Personnel support is provided by reimbursable agreement with the South Pacific Division (CESPD).

Facilities

The Center is located in Davis, California, near the University of California, Davis campus. Facilities include office space for the staff and visitors, a classroom with a capacity for 32 students, a library, a publications and video tape storage center, and computer equipment. The computer hardware consists of personal computers, several engineering workstations and a variety of supporting video, graphics and printing equipment.

Organization and Staff

HEC is organized into five functional units as shown on the accompanying organization chart. HEC was authorized 35.0 full-time equivalent (FTE) positions during FY 1997 and for FY 1998. Those persons employed on permanent status are shown on the organization chart. HEC also employs temporary staff in engineering, computer science and clerical capacities.

Hydrologic Engineering Center
 Permanent Employees
 As of 1 January 1999

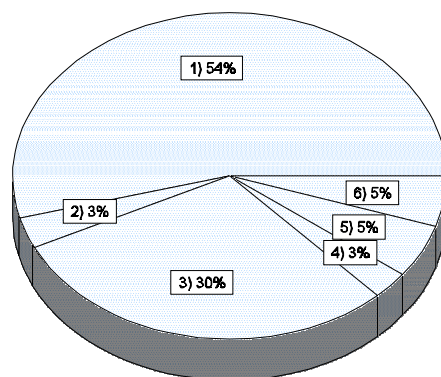
EXECUTIVE			
<i>Darryl W. Davis, Director</i>			
Diane Cuming Adela Pucci		Administrative Officer Executive Secretary (OA)	
PLANNING ANALYSIS		TRAINING	
<i>Michael W. Burnham, Chief</i>		<i>Vernon R. Bonner, Chief</i>	
Vacant	Secretary (OA)	Josie Garcia-Moreno	Secretary (OA)
Penni Baker	Computer Specialist	Marilyn Hurst	Computer Specialist
		Eileen Haramoto	Training Assistant
David Watkins	Hydraulic Engineer	Joan Klipsch	Hydraulic Engineer
Bob Carl	Senior Hydraulic Engineer	Gary Brunner	Senior Hydraulic Engineer
Chris Dunn	Senior Hydraulic Engineer	Mike Gee	Senior Hydraulic Engineer
Bill Johnson	Senior Hydraulic Engineer	Richard Hayes	Senior Hydraulic Engineer
TECHNICAL ASSISTANCE		RESEARCH	
<i>Arthur F. Pabst, Chief</i>		<i>Arlen D. Feldman, Chief</i>	
Vacant	Secretary (OA)	Doug Foster	Secretary (OA)
		Jeff Houghten	Computer Specialist
		Lisa Pray	Computer Specialist
Carl Franke	Hydraulic Engineer	James Doan	Hydraulic Engineer
		Jon Fenske	Hydraulic Engineer
		William Scharffenberg IV	Hydraulic Engineer
Dan Barcellos	Senior Hydraulic Engineer	Tom Evans	Senior Hydraulic Engineer
Bill Charley	Senior Hydraulic Engineer	David Goldman	Senior Hydraulic Engineer
Al Montalvo	Senior Hydraulic Engineer	Harry Dotson	Senior Hydraulic Engineer

Funding

Funding is received from several sources: the Civil Works R&D program, special projects, the Corps-sponsored training program, field office subscriptions for computer software support, and reimbursable assistance. Reimbursable assistance includes work for Corps district and division offices; research and development laboratories; Institute for Water Resources; Planning Division, Civil Works Directorate, HQUSACE; Hydraulics and Hydrology Branch (H&H), Civil Works Directorate, HQUSACE; and other government agencies.

Income & Expenses Summary		
	(\$1,000)	
INCOME	FY 1998	ESTIMATED FY 1999
Research & Development, Direct	\$1,180	\$1,260
Water Control Data System Modernization	\$1,250	\$1,250
Training	\$200	\$200
Numerical Model Maintenance	\$470	\$530
Guidance	\$60	\$60
Mississippi Basin Model	\$60	\$970
Reimbursable Technical Assistance	\$1,990	\$1,430
TOTAL	\$5,210	\$5,700

Expenses FY 1998/FY 1999



- 1) Salaries & Benefits
- 2) Travel, Per Diem & Training
- 3) Professional Contracts & Corps Field Office Technical Transfers
- 4) Administrative/Personnel Support
- 5) Rent, Utilities, Phones
- 6) Computers, Supplies, Materials & Reproduction

Research and Development

Corps field-office needs are the basis for HEC's research program. New research needs are also identified by Corps headquarters and other Federal agencies. Most of the research effort is technique-oriented and emphasizes a generalized solution to specific field problems. Research results are transferred to the field through training and technical assistance projects and through manuals, regulations, and computer software.

Planning, design, construction, and operation and maintenance of today's multiple-purpose water projects requires complex interdisciplinary analyses. These complex problems present major methodological and computational tasks to water resources professionals. Research seeks solutions to these problems through development of systematic methods and the use of advanced analysis techniques.

Research Programs for FY 1998-1999

Research was conducted in 13 work units as described in the following paragraphs. These work units represent specific technical needs identified in the Corps R&D program. HEC manages the Corps "Hydrologic Engineering" R&D Program and performs most of that work. HEC was also involved in the Corps research programs for "Risk Analysis of Water Resource Investments," and "Geospatial Information Systems."

Hydrologic Engineering Research Program

(in priority order)

- River Analysis System
- Catchment Analysis System
- Flood Damage Analysis Package
- Reservoir Analysis System
- Statistical Methods in Hydrology
- Terrain-based H&H Modeling
- Urban Hydrology Methods/Models
- Improved Streamflow Estimation and Project-Aquifer Impact Analysis
- Resolving Water Allocation and Use Conflicts
- Comprehensive Watershed Studies - Internet Resources
- Development of an Initial Data Warehouse for Coralville Reservoir Water Balance Analysis

Risk Analysis of Water Resources Investments Research Program

- Risk-based Analysis for Flood Damage Reduction Studies
- Risk & Uncertainty of Hydrologic Engineering Analysis of Riverine Environmental Restoration Studies (New in FY 1999)

Geospatial Information Systems Research Program (New in FY 1998)

- Flood Damage Analysis Using GIS Technology

Hydrologic Engineering Research Program

The main focus of this research program, since October 1990, has been the development of the next generation (NexGen) of hydrologic engineering software. The NexGen program packages are planned as successors to the widely used existing HEC programs. The software includes many new and updated engineering algorithms and are designed for the interactive, desktop computer environment with graphic user interfaces. Much emphasis has been placed on the engineer-computer interface to enhance the computational power for engineering analyses. The software has a common, distinctive look and feel, uses common software libraries where possible, and will be modular among user interface, graphical and database support, and analytical components.

River Analysis System

This work will produce a consistent set of one-dimensional river analysis software tools for use by H&H engineers in workstation and PC environments. A single geometric representation of the river and floodplain will be used for all simulations; sediment scour, transport, and deposition capabilities will also be included. During FY 1995, the River Analysis System (HEC-RAS), Version 1.0 program was completed, the Hydraulic Reference and User's manuals were published, and the package started distribution in August 1995. The program is a Windows-based standard-step model that computes steady-flow profiles for subcritical, supercritical, or mixed flow regimes. During FY 1996, Versions 1.1 and 1.2 were released to provide error corrections and added program features. Version 2.0 was released in FY 1997 and included several improvements for flow through bridges and graphical editing of cross sections.

Accomplishments and Outlook

An initial test version of the unsteady flow module in HEC-RAS was developed. It provides the basic computational elements for the unsteady flow program, but not all the hydraulic structures features of the full UNET program. In FY 1999, the beta test version of HEC-RAS with unsteady flow capabilities will be released. The User's, Hydraulic Reference, and Application manuals will be updated accordingly. Significant improvements for interfacing with GIS cross-section and inundation-mapping capabilities will also be included.

Catchment Analysis System

This work unit is developing methodologies and numerical models for both continuous and event-oriented simulation of complex flood and low-flow river basin hydrologic processes for the NexGen Hydrologic Modeling System (HEC-HMS). The simulation capabilities developed here will be applicable to planning, design, and real-time water control. The analysis system will be built of modular components with a catchment model as the central component. The modular, object-oriented design will facilitate inclusion of special methods for interaction with river hydraulics, interior area flood analysis, urban runoff, groundwater connections, GIS, etc. A graphic user interface, GUI, was developed to maximize the engineer's ability to prepare, understand, and display data and results.

Accomplishments and Outlook

HEC-HMS Version 1.0 was released in FY 1998. Capabilities for continuous simulation was added to HEC-HMS computational engines and the graphic user interface programming was begun. A draft Technical Reference Manual was completed. Several improvements were made to the Interior Flood Hydrology program.

In FY 1999, applications experience with version 1.0 of HEC-HMS will be reviewed, and program corrections and additions made for release of version 1.1. Continuous simulation capabilities will be incorporated in the program and released as version 2.0. Program documentation and help files will be updated and expanded. The Technical Reference Manual will be published.

Flood Damage Analysis Package

This work unit is developing a next generation of analysis methods and software for flood damage computations. The goal is to enhance the Corps' capability to develop structure inventory information, and to estimate the effects of various project works on flood damage reduction. The next generation Flood Damage Analysis (HEC-FDA) computer program replaces the old FDA package that included the Structure Inventory of Damage (HEC-SID), and Expected Annual Damage (HEC-EAD) programs.

Accomplishments and Outlook

Extensive testing and upgrading of the provisional version of HEC-FDA were performed and Version 1.0 was released in FY 1998. The user's manual was also significantly upgraded. Several enhancements were made to the flood damage computation routines, output reports, and user interface. This work was closely integrated with the Statistical Methods in Hydrology work unit and another work unit in the Risk Analysis R&D Program to ensure appropriate new risk and uncertainty methods were developed and incorporated.

In FY 1999, technical capabilities will be expanded, design and coding for incorporating a front-end user interface consistent with HEC-HMS, HEC-RAS, and initial GIS capabilities will be released as Version 2.0. A training document will be prepared.

Reservoir Analysis System

This work unit is developing a family of reservoir analysis tools to facilitate investigations ranging from reconnaissance-level planning studies to detailed reservoir regulation plan investigations. The family of programs will include the existing HEC-5 for multi-purpose simulation, a reservoir optimization capability, a systems analysis-based reservoir system evaluation methodology for large-scale screening studies, and modular reservoir regulation routines. These reservoir regulation routines can be implemented in real-time analysis for complex flood and low-flow conditions. Field needs were surveyed and major requirements defined. The Prescriptive Reservoir Model (HEC-PRM) was designed, developed, tested, and released; it is a systems analysis model for evaluation/screening of multi-purpose, multi-reservoir systems. In FY97, a multipurpose reservoir model graphic user interface was developed.

Accomplishments and Outlook

In FY 1998, a new operation algorithm was developed and incorporated in a prototype reservoir model. The basic reservoir GUI developed last year was restructured to incorporate the new algorithm. Next FY, the new operation algorithms will be incorporated in Version 1.0 water control software. A beta test version of HEC-RES software and documentation will be released.

Statistical Methods in Hydrology

The objective is to develop a package of hydrologic statistics tools and documentation for use by field offices. These tools will be in the language of the hydrologic engineering profession without the highly statistical and mathematical jargon used by the developers of the theory in other sciences. Flow frequency at multiple stations, stochastic methods, regression techniques, etc., are to be included in this package. Statistical methods for both flood and low-flow hydrology will be developed. These methods will include probability assessments for generated flow sequences. A general design for the Corps hydrologic statistics package has been scoped out and algorithms developed for missing data fill-in. The beta Version 1.0 of STATS was released in FY 1997. Methods for improving regional estimates of skew were investigated and presented to the Corps' Hydrology Committee and the Interagency Bulletin 17B work group.

Accomplishments and Outlook

In FY 1998, the new missing data fill-in algorithm was completed. Design of generalized statistical methods capabilities for HEC-DSS was undertaken. Regional flow frequency estimation methods were documented. In FY 1999, the STATS library statistical routines will be updated per experience with the initial beta version. Documentation for the library routines will be provided.

Terrain-based H&H Modeling

Existing hydrologic and hydraulics models do not adequately represent the spatial variation in meteorologic processes and geographic characteristics. This work unit will develop spatially distributed hydrologic and hydraulic modeling capabilities that can use the remote sensing and GIS data effectively. Digital elevation data will be the primary source of topographic information with which to develop spatially distributed models. Spatial precipitation will be based on both gaged data and radar sensed distributions. These spatial data representations will be used in HEC's next generation H&H modeling projects. A digital terrain modeling capability was developed to support HEC hydrologic models. It identifies and delineates watersheds and rivers, creates the structure for the HEC-HMS model, and geo-references a standard hydrologic grid (SHG) to the National Weather Service's radar rainfall grid (HRAP). The hydrologic model uses the spatially distributed rainfall and watershed information to compute runoff. A method for interpolating gaged precipitation data to a grid (HRAP or SHG) has been completed. Preliminary methods for extraction of cross sections and delineation of inundated areas using digital elevation models (DEMs) were developed. GIS tools were developed to support cell-based NRCS curve number infiltration in HEC hydrologic models.

Accomplishments and Outlook

GIS tools for infiltration (Green and Ampt) and soil moisture accounting methods in HEC hydrologic models will be tested and further developed. Newly developed GIS tools for HEC-RAS were completed with draft documentation. GIS support software for HEC-RAS will be released next FY. Also next FY, a GIS preprocessor for HEC-HMS will be developed and released with documentation.

Urban Hydrology Methods/Models

A methodology for use of appropriate hydrologic and hydraulic simulation models in urban areas will be developed. The need for a more comprehensive modeling capability will be assessed and new models developed as necessary. These new modeling techniques will be incorporated in the HEC-HMS, and HEC-RAS. A state-of-the-practice seminar was held to describe Corps capabilities and needs to leaders in the profession. Attendees from the Corps, other federal agencies, private industry, and academia presented papers and participated in assessing existing technology. In FY 1997, software and guidance was provided to EPA-SWMM model developers for incorporation of HEC-DSS linkages for input and output.

Accomplishments and Outlook

In FY 1998, further development, testing, and implementation of urban runoff and routing algorithms (kinematic wave routing in steep channels, culvert, orifice, and weir flow) for HEC-HMS were undertaken using more detailed hydraulic capabilities of HEC-RAS. In FY 1999, improved urban hydrologic and hydraulic features will be added to HEC-HMS and HEC-RAS. User guidance for analyzing different urban flow regimes will be prepared.

Improved Streamflow Estimation and Project-Aquifer Impact Analysis

This work will develop, document, and deploy a suite of analysis methods and computer routines to enable computation of the rate and volume of water exchange between the ground and the surface. The computations will be designed to make use of readily available information and be tailored to the needs for planning, design and operation of existing and potential Corps' projects. The computations will include analysis of rivers, lakes, reservoirs, aquifers, wells, diversions, and other inflow/outflow sources. Computer programs will be developed using state-of-the-art software engineering methods. Corps groundwater needs and capabilities of the profession have been assessed through field survey, literature review, review of field projects, and participation on the Army Groundwater Modeling committee. Conceptual designs for connection of surface water and groundwater models have been made. A surface reservoir package was developed for the USGS MODFLOW model. A review of available continuous SW/GW models in the profession was drafted. Initial conceptualization of continuous SW/GW interaction for HEC-HMS was made in cooperation with the USGS.

Accomplishments and Outlook

In FY 1998, the review of available continuous SW/GW models was completed. Initial algorithms for the linkage of HMS to MODFLOW for improved continuous simulation were designed and development begun. In FY 1999, testing of the initial HMS-MODFLOW capability will take place and development will continue. This continues to be a cooperative project with the USGS.

Resolving Water Allocation and Use Conflicts

The original objectives were to develop generalized water allocation, conflict resolution capabilities; these were modified based on the response of the field review group. Emphasis is now on analytical methods to assist in Corps studies for reservoir operations where conflicts exist. The HEC Prescriptive Reservoir Model (HEC-PRM) and Linear Programming for Flood Control Operations (FCLP) programs are key components under this work unit. A draft framework document on resolving water allocation and use conflicts was prepared. A letter report was prepared on conflicts associated with the Corps regulatory program. In FY 1996, a seminar on "Resolving Water Allocation and Use Conflicts," was held with 20 invited participants. In FY 1997, the initial version of FCLP was completed.

Accomplishments and Outlook

In FY 1998, enhancements were made to HEC-FCLP to allow better representation of flood damage costs and the efficient solution of very large linear programs. In FY 1999, field testing of the beta version of HEC-FCLP will be completed and version 1.0 released. Conflict resolution information will also be developed via post processing of HEC-RES simulation results.

Comprehensive Watershed Studies - Internet Resources

There are three principal needs addressed by this work unit: (1) the need to increase the ability of Corps offices to quickly and effectively access a broad range of hydrologic/hydraulic and system analysis data information to help in describing a watershed economically, ecologically, socially, and culturally; (2) the need to improve the information base that tells the story of what the management of Corps projects produces in flood damage reduction, navigation, hydroelectric power generation, recreation, fish and wildlife enhancement, water quality, and other project purposes both within and outside the watershed; and (3) the need to develop guidelines for the effective utilization of this information in watershed planning. Literature review was performed and discussions with several Corps offices on watershed studies conducted. Funding reductions significantly limited the start and effort of this work. Because of those constraints emphasis is now on the use of the Internet. In FY 1997, initial efforts were undertaken to explore the role of the Internet in comprehensive studies.

Accomplishments and Outlook

In FY 1998, a framework describing the potential of the Internet in watershed studies was proposed. Web site development ideas and concepts were employed on a field project. Next FY, a test application of the framework will be made.

Development of an Initial Data Warehouse for Coralville Reservoir Water Balance Analysis

Congress directed the Assistant Secretary of the Army (Civil Works) to support the comprehensive Flood Impact Response Modeling System (CFIRMS) through research proposed at the University of Iowa. Initial work is developing a data warehousing system and structure to enable high-speed access to both static and dynamic data sets that might ultimately involve such diverse data streams as digital terrain data, soils, geology, soil moisture, runoff, rainfall, land values, reservoir and channel water levels, flood routing, crop values, urban landscape mapping, archaeological data bases, and critical facilities and capacities. The issues of data registry, dynamic data input and retrieval, security, high-speed access to on-line data, and data sharing protocols (both operational and administrative) must first be addressed. An integrated solution for this data warehouse at the Corps Coralville reservoir was completed.

Accomplishments and Outlook

The initial data warehouse and data input connection's infrastructure was expanded. The data warehouse was tested on selected data sets; installation at the Rock Island District was temporarily made via computer linkage to the University of Iowa system. This work unit will be completed next FY with the addition of more data and installation in the Rock Island District.

Risk Analysis of Water Resources Investments Research Program

Risk-based Analysis for Flood Damage Reduction Studies

This research program is managed by the Corps Institute for Water Resources (IWR). The objective of HEC's work unit is to develop, document, test, and deploy risk-based analysis flood damage computation software and applications methodology for Corps-wide use. The analysis requires that the statistical uncertainty in variables such as flood frequency, flood stage, and flood damage be quantified and included in the analysis. The work is closely coordinated with IWR (economics), WES (hydraulics), and Corps HQUSACE Planning and Engineering Divisions. Extensive technology transfer is accomplished through workshops, new training courses, and guidance documents. The provisional version of the NexGen HEC-FDA program was completed and distributed to Corps field offices in FY 1997. The program is consistent with the risk-based analysis requirements of ER 1105-2-101, and procedures and output defined in EM 1105-2-1619.

Accomplishments and Outlook

The initial public release Version 1.0 of the NexGen HEC-FDA computer program was made in FY 1998. Enhancements to the provisional version included additional accommodating uncertainty functions, new output reports, and better geotechnical assessments for levees/flood walls consistent with engineering and planning technical requirements. In FY 1999, a new front-end interface will be added and Version 2.0 will be released with user's manual and an ETL training document.

Risk & Uncertainty of Hydrologic Engineering Analysis of Riverine Environmental Restoration Studies

A new work unit will be started in FY 1999. The Corps studies and implements riverine environmental restoration projects to protect and enhance the nation's environment. Notable examples include the Upper Mississippi and Kissimmee Rivers restoration projects. Federal policy is that risk-based (risk and uncertainty) analyses be incorporated into the technical studies performed by water resources agencies. Riverine environmental restoration studies require the statistical uncertainty of key variables associated with low- and high-flow regimes affecting the design, maintenance, and operation of the project over its life be quantified and included in the analyses. Low-flow uncertainty variables may include: long-term records, droughts and their persistence, water levels and depths, durations, and seasonal variations. High flows are of interest primarily to assess maintenance requirements and cost and any induced flooding impacts. ER 1105-101 and EM 1110-2-1619 cover the uncertainty analysis requirements for high-flow analysis considerations.

Accomplishments and Outlook

The new work unit will develop, document, and deploy risk-based analysis procedures for hydrologic engineering analysis associated with riverine environmental restoration studies. Emphasis is on defining/developing uncertainty methods for hydrologic variables critical to riverine restoration projects. Conduct training through USACE PROSPECT courses and on-site workshops to transfer application capabilities to field offices. Assist in preparing guidance on the topic.

Geospatial Information Systems Research Program

Flood Damage Analysis Using GIS Technology

Planning flood damage reduction projects requires an integrated participatory approach, the use of a variety of information and data sources, and analysis procedures and results that are easily interpreted by the participants and decision makers. The variety of data and analyses required can easily bring about: duplication of efforts; increased field survey time and costs; complicated spatially distributed displays of results; and loss of information useful to other and future projects. GIS data capabilities together with an analytical software framework, can provide flood damage analyses, and results displays to meet the needs of these complex flood damage reduction studies. Algorithms will be developed and integrated with the HEC-FDA computer program. The work will be coordinated with other Corps GIS activities such as those being developed under the Water Control Data System by CECRL, and other HEC R&D work. This was a new work unit in FY 1998.

Accomplishments and Outlook

Detailed design of approaches for interfacing HEC-FDA with GIS capabilities was completed. The design entails an inter-relational query between a digital terrain model, a digital water surface and a grid-cell or structure inventory. The design allows for aggregation of damages, defined by grids or individual structures, to an index location for predefined floods (stages). A preliminary prototype analysis tool for producing flood stage-damage, with uncertainties, by grid-cell definition was completed. The prototype is also capable of detailing stage-area, stage-structure (number and type), and stage-population function with uncertainties. HEC-FDA accepts the GIS generated aggregated data sets for computation of expected annual damages. Other stage-impact information can be generated directly from the GIS interface tool. The output can be displayed in a variety of formats including tabular reports by damage categories and reaches. In FY 1999, the initial version of the program will be released.

Water Control Data System Modernization

The objective of modernizing the Water Control Data System (WCDS) is to improve Automated Information System (AIS) support to enable the Corps to efficiently and effectively accomplish the water control management component of its Civil Works mission. This includes water control of the more than 600 dams and reservoir projects constructed by the Corps. The modernized WCDS will: a) acquire project status and hydromet data in real-time; b) store, manage, and report hydromet and project data, documents, imagery, and other data; c) model, forecast, and simulate reservoir and river status; and d) perform decision support analysis and information dissemination.

The WCDS modernization project includes replacement of pre-1990 computer and related hardware; upgrades to field instrumentation and communications equipment; and upgrades of existing WCDS software including porting existing products, modifying and upgrading existing products, and development of new software products. HEC is responsible for development of new Corps-wide software for the modernized WCDS. Subsequent sections describe the associated software activities. Major efforts have been completed that include development of system requirements, and the conceptual design of system components. Current efforts are focused on implementation of WCDS Version 1.0 Prototype and a pilot application to the Bald Eagle Creek area of the West Branch Susquehanna River Basin, Pennsylvania.

The WCDS modernization project is making extensive use of products developed under the Hydrologic Engineering R&D program. In several instances, noted in the following descriptive information, joint R&D and WCDS funding is supporting product development and integration into WCDS.

Data Capture

This WCDS component task provides water control sites connectivity to required data sources including National Weather Service (NWS)-AWIPS (including NEXRAD radar products), NWS-AFOS, GOES/DOMSAT satellite data links, land based radio, ALERT receive sites, and cooperating agency networks.

Accomplishments and Outlook

In preparation for deployment of the WCDS software, a prototype of the Data Capture process was developed and demonstrated at HEC in June 1998. A prototype data acquisition activity was set up from Baltimore District to simulate the Data Capture activities which will be encountered during routine operation of the WCDS software. Files containing AFOS data were sent from Baltimore District to HEC where the WCDS prototype implementation was able to access the data. After the prototype demonstration, a more general design was developed and is being implemented. The design allows for two or more redundant Data Capture processes which receive data simultaneously. Data can be received as a stream or as individual files. As data is received, only one of these Data Capture processes feeds data to the WCDS software for posting to the Oracle database. If one Data Capture process fails, one of the other processes takes over. If the posting process fails, then the Data is "re-played" when it comes back online.

Future activities include an initial deployment of this capability with version 1.0 of the WCDS software and refinement of the initial design after some experience is gained in its operation. The initial implementation of the Data Capture software will be designed to work with both GOES and AFOS formatted data using a data stream source or a source of individual files.

Data Decoding, Transformation, and Validation

The tasks involved include: 1) design and implement working prototype of the WCDS data capture, decoding, transformation and validation limited to Standard Hydrologic Exchange Format (SHEF) data; 2) design and implement decoding software and graphical user interface for the creation of decoding criteria associated with SHEF and GOES data; 3) develop detailed design of conversion of incoming data; and 4) provide for multi-level screening and validation of raw data in a workstation environment incorporating a well designed graphical user interface.

Accomplishments and Outlook

A working prototype of the WCDS data capture, decoding, transformation and validation were made functional and used in the Baltimore District's Bald Eagle Basin demonstration. Programs SHEFIT, GOESIT, and DecodeProcedure were developed and tested for use in the decoding of SHEF and GOES time series data. A graphical user interface for the SHEFIT decoding criteria was developed. The design of the graphical user interface for the GOESIT decoding criteria as started and will be completed in time for use in the WCDS deployment scheduled in the first part of next year. Work continued on the design and implementation of the transformation and validation components of the WCDS work.

Data Base System

Development of data base technology will supply information of a wide variety such as: hydrologic data, meteorologic data, water quality data, project descriptions and design parameters, manuals, reports, project documents, geographic information, spatial data displays, maps, satellite images, and ultimately sound and video. This will provide the means and standards to have a common nomenclature and structure to data bases located in all Corps of Engineers WCDS computer systems.

Accomplishments and Outlook

Within the context of a WCDS Version 1.0 Prototype Software System, a Data Base Interface (DBI) application was designed, developed, and demonstrated. Other WCDS components will access and store data by passing data objects to the DBI for storage and retrieval from the Oracle relational data base management system (RDBMS). An application with a graphical user interface was also designed, developed, and implemented to define and edit location and time series identity and definition information. This application makes use of the WCDS messaging, the DBI, and the Oracle RDBMS and provides a verification of overall functionality. The software developed in this application is reusable in other WCDS applications wherever there is need to define or edit locations or time series. Preliminary designs for the Version 1.0 WCDS Software System were also completed.

The Version 1.0 Prototype data base subsystem (DBI and Oracle) will be modified to manage time-series data and location information as they appropriately move between WCDS applications and the WCDS Oracle data base as specified for Version 1.0 requirements. The version 1.0 prototype data definition and viewing application will be modified to a version 1.0 level of functionality for WCDS software subsystem. The modifications will include addition of a data cache in the DBI, management of data units, management of time zones, inclusion of paired data, and more sophisticated management of location definitions.

Application/Data Base Interface, Data Reporting and Dissemination

A system for retrieval and dissemination of water control data within the office, the Corps, and the general public is being developed. Design of the system includes retrieval software which will access and display data from the water control database. The system will rely on current Internet browser technology for easy access and display of the information from the database. Script processes on the water control server will provide the mechanics to display the text and graphics. Procedures for automatic updates and ad-hoc requests are also under design. The system will provide special access for Corps functions such as Public Affairs and Emergency Operations for display of sensitive information not accessible to the general public.

Accomplishments and Outlook

The major accomplishment for FY1998 was the development of a prototype implementation of the Data Dissemination process for use with the WCDS software. The prototype consisted of a WW Web server which had Web pages showing data and images from Bald Eagle Creek, a pilot study area located in Baltimore District. The software was demonstrated at a meeting held at HEC on the 23-25 of June 1998. At the meeting, a simple product interface was demonstrated which allows the user to generate dynamic information from the WCDS software. Web pages depicting "Current Conditions," "Model Results," and "Inundated Area" were used as examples of this capability. The Web pages are generated dynamically in the WCDS software from events such as a mouse click or clock event. Script processes are invoked which read the data from the database, generate the Web pages, and then post the pages to the Web server.

Future plans call for continued development of the WCDS Web pages so that users can have a more representative selection of the WCDS capabilities and data. Other work calls for the development and enhancement of the Data Dissemination user interface which will allow a more general control of the Data Dissemination process.

Effort will also be focused on the hierarchical design of the Web servers. At this time, a public server and a separate Corps-only server are envisioned to provide information to users. The public server would be accessible from the Internet while the Corps-only server would be only accessible from the Corps CEAP network.

Data Archiving

This task provides an archiving system for the WCDS data base system. Archive files will be organized to provide logical groupings of related data. Operational data from automated data acquisition will be organized to archive both "raw" and processed information. Large data sets will be partitioned into logical groupings by geographic region, calendar year, and/or data category. Automated means will be provided for periodic archiving and as needed purging of information from the WCDS data base. Means will also be provided for automated retrieval from the data archive and placement into the WCDS data base or standard dissemination files.

Accomplishments and Outlook

Data Archiving was included in the requirements and software design process being overseen by the data base SDT Team. The data archiving system will be designed, developed, and implemented.

Flow Forecasting, Forecast Evaluation

Development of an effective and efficient capability for runoff forecasting for a broad range of storm-runoff and low-flow conditions is planned. Provisions will be made in the structure of the forecast model to allow for incorporation of spatially distributed inputs and parameters. The input and data-handling structures of models will enable convenient specification and centralized interfaces to the model data base. The model will permit parameter-state updating based on real-time feedback. In addition, the model will be coupled with hydraulic, reservoir system, and damage analysis models. The forecast software will utilize components of the Hydrologic Modeling System (HEC-HMS), which is being developed under the Catchment Analysis System work unit of the Hydrologic Engineering R & D program.

Accomplishments and Outlook

Capability to use distributed (cell-specific) SCS Curve Numbers with the ModClark method was incorporated in HEC-HMS. Capability to store basin states (values of state variables) associated with losses, runoff transformation, baseflow and routing was incorporated in HEC-HMS. Requirements specifications for continuous moisture accounting were developed. The capability to save/view/edit basin states, and to "hot-start" a simulation from saved basin states was implemented. The Meteorological Forecast Processor (MFP) which will enable formulation of future-precipitation scenarios for use in forecasting has been developed. The preprocessor Hydrologic Forecast Processor (HFP) which enables adjusting runoff parameters for forecast-specific application of HEC-HMS was also developed. An initial implementation of moisture accounting capability was tested. Work proceeded on implementation of snow simulation.

Efforts this next year will further develop the soil moisture accounting capabilities to permit grid cell computations. Algorithms will be developed to provide parameter adjustments based on observed system conditions.

Reservoir System Simulation

The purpose of this work is to incorporate a family of reservoir tools into the WCDS. The reservoir analysis tools for flood and complex low-flow conditions are to be developed under the Hydrologic Engineering R&D program, Reservoir Analysis System Work Unit. Planning for the general reservoir capabilities include an assessment of real-time requirements to ensure that model development can also support water control.

Accomplishments and Outlook

During FY 1998, the pilot implementation plan was completed in October. Under the Hydrologic Engineering Research Program, the reservoir model design was completed early in the FY. A prototype reservoir model implementing the design was completed, and an existing reservoir GUI modified to support the prototype. The prototype is implemented in WCDS Version 1.0. WCDS funds were used to develop model data and implement the reservoir model for the demonstration pilot study.

During FY 1999, the reservoir model will continue to develop to meet Version 1 goals and development for Version 2 will be initiated. Program documentation for Version 1 will be developed in support of the initial installation, planned for four Corps offices.

River Hydraulics, Stage Forecasting

The initial focus was on hydrodynamic modeling, as represented by the current application of HEC-UNET to develop a stage forecast model on the Mississippi River. A Hydrologic Engineering R&D work unit is developing the River Analysis System (HEC-RAS) computer program to provide steady, unsteady and sediment transport functions. The objective of this task is to incorporate HEC-RAS within the water control system to provide steady and unsteady flow modeling.

Accomplishments and Outlook

In FY 1997, the requirements for stage forecasting were developed, prioritized, and the costs estimated. A conceptual design document was developed, based on the requirements. A pilot implementation, using HEC-RAS was defined and work initiated to start development of a multi-platform GUI to run HEC-RAS. Under the Hydrologic Engineering Research Program, the River Analysis System (HEC-RAS) Version 2.1 was released in October 1997, completing the steady flow model.

During FY 1998 HEC-RAS was integrated into the WCDS environment. The software was tested by applying it to the Bald Eagle Creek pilot study. Under the R&D program, HEC-RAS development for unsteady flow has started, with the goal of having a limited function program operational by FY99 end.

Flood Impact Analysis

The HEC Flood Impact Analysis (HEC-FIA) computer program is designed to be fully integrated with the Water Control Data System with capabilities to: 1) provide ready assessment of flood impacts for forecasted and/or observed events, and 2) post flood assessments of Corps project benefit accomplishments. Hydrographs are normally retrieved via HEC-HMS and HEC-RSS system analysis results. Analyses are performed by impact areas that include computing urban damage flood by categories, agricultural damage by crops, number of structures flooded by categories, area flooded, and population impacted. The seasonal variation in potential crop damage and effects of previous events are considered in the analyses. Results are displayed by impact areas, Corps districts, states, Congressional districts, counties, communities, and flood districts. Access to, control, and results visualization are via the Control and Visualization Interface (CAVI) through its graphical representation of the watershed and river system.

Accomplishments and Outlook

Version 1.0 of the program was undergoing final testing at the end of the fiscal year. Preparation of the Version 1.0 user's manual was also ongoing. The computation code was upgraded, graphical users interfaces, and links to the CAVI were developed during the year. Design of GIS computations and preliminary testing of the methods were performed during the year. Data assembly and testing of the program for Bald Eagle Creek demonstration project was conducted with the assistance of the CECRL/Remote Sensing Center and the Baltimore District.

The HEC-FIA Version 1.0 will be completed early in FY 1999 and deployed in four district offices. This includes fully integrated links with the CAVI and HEC-FIA. The user's manual will also be completed and included in the deployment. Additional work in FY 1999 will focus on enhancing the GIS capabilities and links and provisions of added output results, warnings, and help messages.

System Integration, Implementation, and Management

This task provides standards for the development of components that will integrate with each other through database and control interfaces. Included are: development of standardized software architecture and file directory structure; a common scripting language across all products that will control execution; generalized messaging capability to permit processes to communicate with each other during their execution; libraries of shared functionality for use by multiple components; a programming environment that will provide flexibility in delivery of communication, database, modeling and graphic products in a changing hardware/software marketplace.

Accomplishments and Outlook

Tasks that were accomplished in FY 1998 included; support of the Version 1.0 Prototype implementation, the development and testing of the messaging system used to pass messages between all system components, methodologies to pass data objects between system components were provided. The directory naming structure was defined for use by all system components and modeling processes.

This next year will focus on deployment of the Version 1.0 software to four field sites (Baltimore, Huntington, Omaha, and Portland). The message system will be extended by addition of a message manager. The alarm system will be implemented to provide active notification of data flow or other system anomalies.

Application of GIS and Image Technology

Improvement to water-control decision making and operations, and hydraulic and hydrologic analysis will be accomplished. These objectives can be broken down into four areas: 1) visualization of GIS data, 2) integration of GIS and WCDS databases, 3) interpretation of remotely sensed images, and 4) implementation of RS/GIS tools.

Accomplishments and Outlook

GIS applications were successfully integrated into the WCDS pilot application. CorpsView was used to display map information and data held in the WCDS database. GIS-based programs generated inundation maps from HEC-RAS model results as part of the integrated WCDS system operated through the WCDS CAVI. A systematic approach to the use of GIS data in flood impact analysis was developed in cooperation with the Baltimore district and implemented in the WCDS pilot application. CorpsView was extended to include the display of imagery from digital project notebooks.

In FY 1999, GIS activities for WCDS will include field support for the districts installing version 1.0 of the WCDS, and continued development of GIS tools for use in the WCDS. CorpsView will be extended to provide active monitoring of time series data. Methods for using remote sensing data in model preparation will be developed. GIS integration with flood impact analysis will be improved.

Control and Visualization Interface

The Control and Visualization Interface, or CAVI, oversees and controls the operation of the functional modules. It includes mechanisms for facilitating parameter adjustments, spatial and temporal visualization of observed and forecasted information, operation control of the modeling system, and an evaluation capability of pertinent information. The CAVI will provide access to both the current observed states of the water system and the results from different forecast scenarios. Observed and forecasted information will be displayed graphically, both in traditional two dimensional plots, and in spatial graphics, using schematic, map or photographic/image backgrounds.

Accomplishments and Outlook

A functional prototype program was developed for the Bald Eagle Creek pilot basin. The program was built using the Java programming language in a client-server architecture, and installed on a Sun Solaris (UNIX) workstation. The program provides a mechanism for users to view current watershed conditions, modify modeling parameters, execute models, and view the results. Users identify basin locations for viewing graphs or tables of data for that location by selecting icons from a basin map using the mouse. The models controlled by the CAVI include HEC-MFP for specifying future precipitation, HEC-HMS for modeling the basin hydrology, HEC-RSS for modeling reservoir operations, HEC-RAS for modeling river stages, HEC-FIA for determining damages, and access to Arc/Info for inundation mapping.

The program will be further developed to a Version 1.0 release level. It will be installed at four Corps offices, along with the other WCDS software. It will be able to be executed in a "client" mode on a different machine than where the models are run (i.e., the server), such as a PC running MS Windows while the server is on a UNIX workstation.

Field Application Assistance

This provides field offices with assistance during the pilot testing phase of the WCDS modernization project. This task is further intended to provide assistance with hardware/system software advice. Assistance takes the form of limited pilot implementation of software components at selected Corps locations.

Accomplishments and Outlook

Field Application Assistance activities for FY1998 consisted a variety of tasks. Help was provided on several existing Water Control software packages during the year such as "REPGEN," "SHFDSS," and "DSPLAY," where usage errors occurred or small program fixes were implemented. Also, help was provided in configuring and using the "MON/VUE/IDX" suite of software.

As far as new Water Control programs are concerned, support activities centered around two of the newer programs, the "File Delivery System(FDS)" and the "gridLoadXMRG" packages. In both cases, help was provided in setting up and using the software. Other calls were also received requesting information on many of the other gridded data loading and manipulation programs. These programs include gridLoadStage1, gridLoadHDP, gridLoadNetCDF, and gridUtil.

Mississippi Basin Model System (MBMS)

Following the 1993 flood in the Missouri and Mississippi River basins, Congress tasked the Secretary of the Army to conduct a system-wide study of floodplain management practices and policies of the Upper Mississippi and Lower Missouri Rivers and their tributaries. Computer program UNET was the primary hydraulic analysis tool used in the floodplain study. As a follow-on activity, the UNET model was modified and integrated with existing WCDS to provide for real-time stage forecasting.

UNET simulates one-dimensional unsteady flow through a network of open channels. The components of a UNET flow network can range from single channels to a complex looped system. UNET can simulate flow into and out of storage areas; lake-like regions that can either provide water to, or divert water from, a channel. In this situation, the storage area water surface elevation will control the volume of water diverted, which affects the shape and timing of downstream hydrographs. With the capability to simulate levee overtopping or levee breaches into storage areas, UNET can simulate large flood events.

The MBMS project developed an integrated unsteady-flow stage forecast model for the Missouri, Illinois, and Mississippi Rivers and their tributaries. The upper basin Districts prepare their forecasts and pass that information to downstream offices (e.g., St. Louis). St. Louis then brings the information together with their forecast and provides the results to Vicksburg, which completes the flow routing to the Gulf of Mexico. UNET model data developed for the floodplain management study was used to start this project. Under CECW-EH management, HEC coordinated project efforts, developed and documented additional UNET features, and provided system support. The Cold Regions Research and Engineering Laboratory developed a GUI to facilitate model application for forecasting. Field offices developed and applied the UNET models. The Waterways Experiment Station Coastal and Hydraulics Lab developed linkage between a two-dimensional flow model and UNET. HEC completed this project in FY 1997. Study and software documentation, and installation of forecasting software at District offices, was continued in FY 1998. Expanded topographic mapping of floodplain areas for the Upper Mississippi and Missouri Rivers was obtained in FY 1998 as a separate work item. Integration of this data into the existing UNET forecasting models will occur during FY 1999.

Hydrologic Engineering Guidance Program

Two Corps guidance documents were under preparation by HEC this FY, both were additions to existing EM's.

An Applications Guide will assist Corps personnel in performing formulation and evaluation of flood damage reduction studies with risk-based analysis is under preparation. An initial draft of the document was completed. It will serve as a training guide to assist in formulating and evaluating flood damage reduction studies using risk and uncertainty. Version 1.0 release of the HEC-FDA computer program will be used to illustrate this analysis.

An appendix on Standard Project Flood Analysis is being added to the Flood-Runoff Analysis, EM 1110-2-1417. The old Standard Project Flood EM was reviewed and plans made for inclusion in the other EM.

Training & Technology Transfer

The training activities of HEC are designed to increase the technical capabilities of the Corps field offices to meet needs and solve problems in hydrologic engineering and water resource planning. The training provides instruction in technical concepts and methods, and assists field offices in applying the methods to complex water resource problems and studies. This technology transfer is carried out through a variety of training courses and working sessions, with the emphasis on practical applications, using appropriate technology to solve real-world problems.

Training Programs

HEC training and technology transfer activities include the following:

- Seminars
- Workshops
- Training Courses
- Professional Development Assignments
- Video Tapes
- Technical Publications
- HEC Internet Homepage
- HEC Computer Software and Support

Recent activities are summarized below:

Seminars

Seminars provide a forum to discuss field problems and potential solutions, and to identify the need for new techniques. The papers presented by participants are published as seminar proceedings. A seminar on "Risk-based Analysis - Lessons Learned," was held in October 1997, to share experience and address various issues in the application of risk and uncertainty in flood damage reduction planning. The proceedings were published as HEC SP-28.

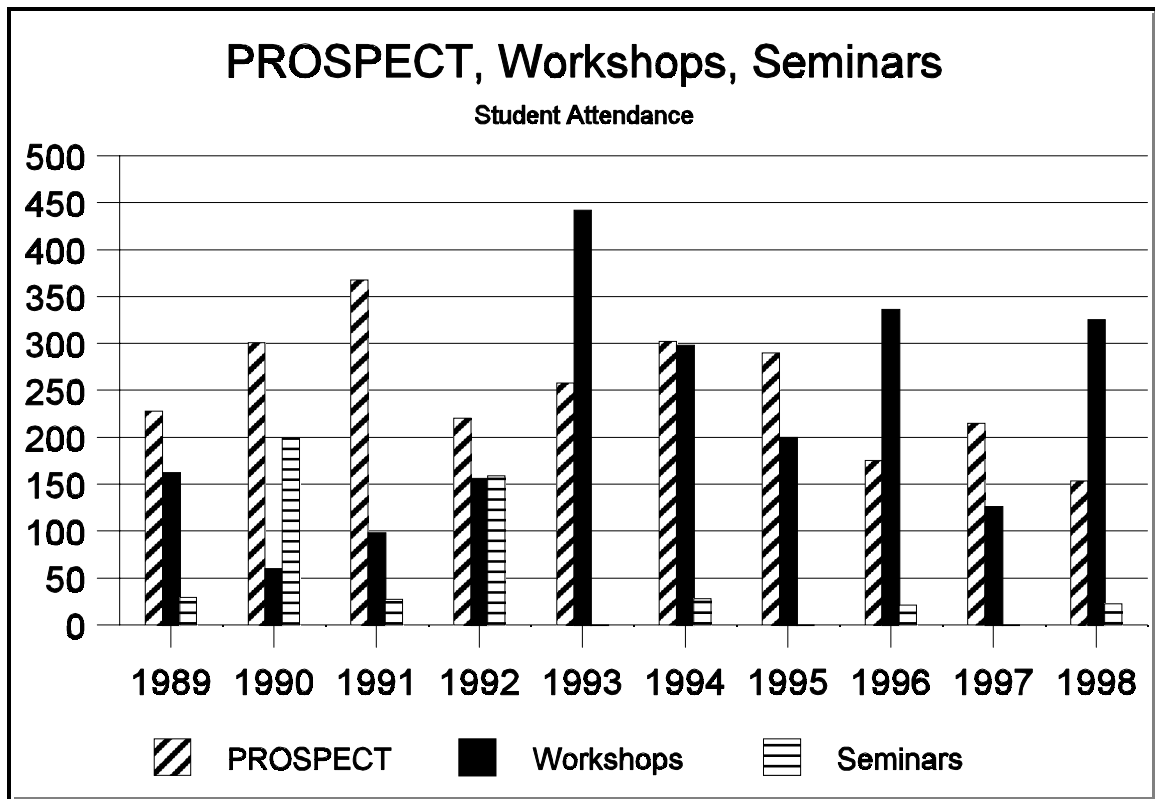
Workshops

Workshops are conducted each year, on a reimbursable basis, at the request of individual district or division offices. The workshop may be similar in content to one of the regular courses, or it may focus on a particular need for which training is not available elsewhere. The duration of these workshops range from one day to one week. They are usually held at the requestor's office to allow greater participation by Corps office staff, as well as local, state and other federal agencies. During FY 1998, HEC conducted 12 workshops for a total of 35 days of training and 325 students. Topics presented included WCDS real-time working sessions, HEC-RAS, HEC-HMS, risk-based analysis, and reservoir operations/HEC-5.

Training Courses

Recently, six courses are conducted each year under the Proponent Sponsored Engineers Corps Training (PROSPECT) Program. The HEC courses presented in FY 1998 and being offered in FY 1999 are shown in the following tables. Courses are usually one week in duration, and include formal lectures and practical problem-solving workshop sessions. Guest instructors from other Corps offices, universities and private industry are invited to participate. These instructors supplement the capabilities of the Center's staff.

A ten-year summary of attendance in courses, workshops and seminars is shown in the bar-chart below. High seminar attendance in 1990 and 1992 reflects the Water Quality Seminars HEC previously coordinated.



HEC FY 1998 PROSPECT TRAINING SCHEDULE

Course Title	Date	Length (weeks)	Number Students
Flood Damage Analysis	17 - 22 Nov 1997	1	24
GIS - Hydrologic Engineering	8 - 12 Dec 1997	1	30
Hydro Data Mgt. HEC-DSS	9 - 13 Feb 1998	1	31
Flood Hydrology, HEC-HMS	2 - 6 March 1998	1	28
Statistical Methods in Hydrology	11 - 15 May 1998	1	20
Groundwater Modeling	13 - 17 July 1998	1	20
	TOTALS:	6	153

HEC FY 1999 PROSPECT TRAINING SCHEDULE

Course Title	Date	Length (weeks)	Number Students
Basic HEC-RAS	26 - 30 Oct 1998	1	24
Risk-based Analysis	16- 20 Nov 1998	1	15
GIS - Hydrologic Engineering	12 - 16 April 1999	1	
Flood Hydrology, HEC-HMS	17 - 21 May 1999	1	
Water and the Watershed	12 - 16 July 1999	1	
Groundwater Hydrology	16 - 20 Aug 1999	1	
	TOTALS:	6	39

Professional Development Assignments

HEC initiated a formal Professional Development Program during FY 1992. The program provides broad training and work experience to candidates interested in hydrologic engineering and planning analysis methodologies. It provides an opportunity to participate in challenging studies in the Research, Technical Assistance, Training, and Planning Analysis Divisions. Selected candidates will investigate new techniques which, in many instances, have received only limited field application. Primary areas of interest include: watershed hydrology, river hydraulics, reservoir system analysis, statistical methods, and water resources planning studies involving risk and uncertainty, flood damage and plan formulation, and water management.

Video Tapes

Since 1974, HEC has made video tapes of selected training course lectures. The tapes are intended to supplement the training program by providing the course material to those unable to attend courses. These tapes are available as recorded to Corps offices on request. Copies are available to all others for the cost of duplicating and mailing the tapes. Approximately 350 tapes are available, and the annual distribution varies from 100 to 400 tapes.

Technical Publications

HEC focuses a substantial portion of its resources on the development and documentation of applications software. Documentation includes user's manuals for the software, training documents, technical papers, research documents, project reports, and seminar proceedings. Many are placed on our Web site; hundreds of copies of documents have been downloaded this past year. New and revised documentation issued during FY 1998 are listed below.

Computer Manuals

- CPD-1a HEC-1, Flood Hydrograph Package, User's Manual, Version 4.1, September 1998.
- CPD-68 HEC-RAS River Analysis System, User's Manual, Version 2.2, September 1998.
- CPD-69 HEC-RAS River Analysis System, Hydraulics Reference Manual, Version 2.2, September 1998.
- CPD-70 HEC-RAS River Analysis System, Applications Guide, Version 2.2, September 1998.
- CPD-74 HEC-HMS, Hydrologic Modeling System, User's Manual, Version 1.0, March 1998.

Project Reports

- PR-36 Mississippi Basin Modeling System Development and Application, April 1988.
- PR-37 Technical Considerations for Alamo Lake Operation, April 1998.

Seminar Proceedings

SP-28 H&H Workshop on Risk-based Analysis for Flood Damage Reduction Studies, Pacific Grove, California, 20 - 22 October 1997.

A catalog of publications is available on request, and is on the HEC Web page. HEC provides publications to Corps offices and places most publications into the National Technical Information Service (NTIS) system for general distribution. NTIS reference numbers are listed in the HEC publications catalog. Their address is: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; telephone (800) 553-NTIS, FAX (703) 321-8547. Additionally, HEC is placing computer program documentation and other documents on the HEC web site.

HEC Internet Homepage

HEC has developed a WWW homepage (www.hec.usace.army.mil) to provide information and major computer programs and documents. Information is provided under six categories: HEC Organization, Visitor Information, Training Program, Publications, Software and What's New. Current copies of our Newsletter, Catalogs, and Annual Report are available to all. Corps offices may also keep up with HEC activities documented in the Quarterly Report. The NexGen computer programs and documents have been made available as they are released. Also, some of the earlier HEC programs have been provided. Example usage for June 1998 shows an average of 4,093 file transfers per day. Daily requests range from 1,329 to 6,361. The majority of the requests were from the USA; however, foreign requests came from 56 countries, with over a 1,000 requests coming from: Australia, Brazil, Canada, Germany, Spain, and Italy.

HEC Computer Software and Support

HEC has been developing computer programs for hydrologic engineering and planning analysis procedures since its inception in 1964. Software has evolved from computerized procedures to complex modeling systems. The software runs on PC-DOS compatible computers, UNIX workstations and Windows PC's. Executable PC programs are made available to non-Corps' offices through NTIS and a network of program vendors.

For the older PC-DOS programs, HEC has developed a package concept that provides more convenient application of batch processing programs. A menu provides for naming necessary program files, creating and editing input data with the COED software, running application program(s), and reviewing output with the LIST software. Once the files have been defined, the various programs can be executed directly from the menu. Additionally, COED can provide on-screen displays of program input requirements for each batch program. These on-screen displays are based on the input description provided in the associated user's manuals. Packages exist for HEC-1, HEC-2, HEC-5, HEC-5Q, HEC-6, and UNET.

The newer programs, like HEC-RAS, HEC-HMS, and HEC-FDA, are being developed for windows-based engineering workstations. HEC-RAS is a one-dimensional river hydraulics package designed to succeed HEC-2. The Hydrologic Modeling System (HEC-HMS) is a watershed model designed to succeed HEC-1, and the Flood Damage Analysis package will succeed the earlier multi-program package and includes risk and uncertainty in the analysis. At this time, HEC-RAS version 2.2, HEC-HMS version 1.0 and HEC-FDA version 1.0 have been released.

Software Library

The following is a list of the primary software, by technical subject. Brief descriptions and computer hardware/software requirements for the programs are contained in the Computer Program Catalog, which is available upon request, or on our homepage.

<u>Numerical-Model Area</u>	<u>Primary Software</u>
Hydrology	HEC-HMS, HEC-1
River Hydraulics	HEC-RAS, HEC-2, UNET, HEC-6
Analytical Planning	HEC-FDA, HEC-PBA
Statistical Methods	HEC-4, FFA, STATS
Reservoir Systems	HEC-5, HEC-PRM
Water Quality	HEC-5Q, WQRRS
Water Control	HEC-1F, DATCHK, DATVUE
Data Management	HEC-DSS, DSPLAY, DSSUTL
Interior Flood Hydrology	HEC-IFH

Software Support

Computer program support is designed to provide user assistance and to produce and distribute documentation for newly developed and improved software. Beginning in FY 1997, support for maintaining, documenting and distributing HEC software is funded directly via subscription fees from Corps offices. Accordingly, HEC only provides full program support and distribution to those subscribing offices. Other foreign and domestic government agencies, academic institutions, businesses, and private citizens may obtain the software from either the National Technical Information Service (NTIS) or vendors. Most software at NTIS is for use on an MS DOS Personal Computers. Their address is National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; telephone (703) 487-4650, FAX (703) 321-8547. The cost includes software and documentation but does not include any technical support.

Vendors are public and private organizations that have obtained software from HEC and have agreed to distribute the current versions to requesters. Fees for software and services are determined by the vendor. In addition to program distribution, many of the vendors provide user support and other services. Separate domestic (US) and foreign vendor lists are maintained by HEC and will be furnished upon request. Software not available from NTIS or vendors may be obtained directly from HEC.

Technical Assistance Projects

The technical assistance program provides assistance and guidance to requesting Corps field offices in the application of hydrologic engineering and water resources planning analysis techniques. Technical assistance activities are conducted on a cooperative and reimbursable basis. These activities enable HEC staff to maintain close contact with Corps personnel in district and division offices and to evaluate the effectiveness of new technology in a project application mode.

Each HEC division assists Corps offices in technical studies. The assistance varies from brief reviews of work done by others, functioning in an advisory role during the conduct of a study, to complex applications modeling involving a team of HEC and field office staff.

FY 1998 Accomplishments

FY 1998 technical assistance funding was \$1,690,000. Assistance was provided to 19 Corps field offices, as well as, Headquarters (CECW), Institute for Water Resources (CEIWR), the Corps Cold Region Lab (CECRL), University of California, Davis (UCD), State of California and Metropolitan Water District of Southern California, Panama Canal Commission, and the National Institution for Building Sciences (NIBS).

Surface Water Hydrology

(\$215,000)

HEC's surface water hydrology technical assistance during the fiscal year cover a variety of topics. These include: arranging and participating in the Corps Hydrology Committee sponsored Risk-based Analysis seminar and committee meeting; flood warning-preparedness program assistance; interior flood hydrology assistance; snow and PMF studies; and assistance on several studies involving the new HEC-HMS applications. Also, case studies were performed for policy studies on the impact of wetland on flood frequency and magnitude.

CECW,	Headquarters: Civil Works Committee on Hydrology
CEMVD,	Missouri River Division: Interior Analysis Assistance
CESAM,	Mobile District: Flood Warning-Preparedness Program Assistance
CESPK,	Sacramento District: Sacramento and San Joaquin Comprehensive Basin HEC-HMS Study, Kaweah PMF Analysis, Reno Flood Warning Study, Kings River Snowmelt Modeling
CESPL,	Los Angeles District: HEC-HMS Los Angeles Analysis
CESWG,	Galveston District: HEC-HMS Technical Assistance
CECRL,	Cold Regions/Remote Sensing Lab: Remote Sensing Snow Cover Analysis
CEMVS,	St. Louis District: Mod Clark Applications of HEC-HMS

Water Quality

(\$20,190)

HEC assisted CEMVP, St. Paul District with a water quality analysis of proposed Devils Lake pumping. The study contractor, RMA, provided an HEC-5Q analysis of the water quality of water pumped from Devils Lake as part of an impact analysis.

Groundwater Hydrology

(\$103,000)

HEC assisted CESP, Sacramento District, in continued calibrating the Tooele Army Depot's groundwater quantity model and developed a companion pollutant transport model. A review was provided of the available information on potential Lockheed groundwater contamination near Burbank, California.

Water Control

(\$74,000)

Assistance and consultation was provided to the Sacramento Water Control Section in adopting software to a new hardware environment. Additional capabilities were developed to improve data analysis, and reporting.

Work was completed on a review of the database requirements for the Upper Rio Grande Water Operations Model (URGWOM). The Albuquerque District participates along with the US Bureau of Reclamation and several other Federal, and state agencies to perform joint regional water management function. A report was furnished recommending the adoption of the USBR's Hydrologic DataBase (HDB) as the primary data system. This quality facilitates interfacing to the Riverware reservoir model and water rights accounting procedures.

CESWA, Albuquerque District: Development of Guidelines for numerical modeling
CESP, Sacramento District: Porting WCDS/Harris
CECW, Headquarters: WCDS Setup, Maintenance

Reservoir Systems

(\$563,000)

The HEC Prescriptive Reservoir Model (HEC-PRM) was applied in South Florida. This Jacksonville District study studied existing and alternative water allocation for the greater Miami urban area and the environmentally sensitive Everglades. HEC-PRM was also applied for the Los Angeles District study at Alamo Dam to study the reservoir operations associated with lake five-year drawdown maintenance inspection requirements, bald eagle pool nesting, and the downstream Bill Williams Wildlife Area. Linear Program capability was used in a Rock Island District study to evaluate reservoir flood control operations for the Iowa/Des Moines River system. Support to the Mobile District continued in the application of the HEC-5 model to the ACT/ACF Study.

HEC is developing reservoir system models for two basins to assist with a review of flood operations. Also to be developed is a system model using HEC-5 for reservoir simulation and HEC-FCLP flood reduction optimization. Models will be calibrated using several recent floods and then they will be utilized by the District to evaluate alternative operations.

Panama Canal Commission: Canal Capacity Evaluation. A water resource evaluation was started near the end of the FY to review flow data development and to develop reservoir models to evaluate the existing system and proposed alternatives. We are reviewing the flow data process and developing HEC-DSS procedures to automate the process. An HEC-5 reservoir system model will be developed to evaluate the existing system.

Tech transfer workshops provide training on HEC-DSS and the HEC-5 software used in the evaluation. HEC is also developing an HEC-PRM model of the existing system to assist in the evaluation of the operation rules.

CESAJ, Jacksonville District: South Florida/Everglades
CENCR, Rock Island District: Iowa River Basin Reservoir Operations
CESPL, Los Angeles District: Alamo Dam/Bill Williams River Corridor Study
CESPK, Sacramento District: Sacramento and San Joaquin Basins Comprehensive Study.

River Hydraulics **(\$185,000)**

An HEC-RAS model for Santa Ana River was developed from the Los Angeles District's WASURO model data. Also, HEC-RAS was modified to add program features to model floating debris on bridge piers and air entrainment affect on stage, and to output levee freeboard. The project also demonstrated the program's ability to model flow transitions over drop structures and mixed-flow hydraulics. With support from FPMS, HEC updated the HEC-RAS course materials to reflect version 2.0 capabilities, which were used in several workshops. Also, a paper on HEC-RAS ability to import 3-D terrain data for modeling and to write output was developed and presented at the Association of State Flood Plain Managers Conference. Additionally, the Cold Regions Research and Engineering Lab is working with HEC to add ice modeling capability to HEC-RAS. Several model applications assistance projects were undertaken.

CESPK, Merced Country Streams
CECW, Flood Plain Management Services (CEFPMS): Flood Plain Hydraulics Guidance
CEMVS, St. Louis District: Mississippi River Basin UNET Modeling
CEPOD, Pacific Ocean Division: HEC-RAS Wailupe Stream Model
CESWG, Galveston District: UNET Model Review
CECRL Cold Regions Lab: Ice Cover Hydraulics

Flood Damage **(\$249,000)**

HEC initiated a study for HQUACE to develop methods of better analyzing and communicating the residual risk associated capacity exceedance events of flood damage reduction projects. Assistance to the Institute for Water Resources was provided by participating in contract review with Marshall and Swift to assure capability with the HEC-FDA program. HEC is assisting the Sacramento District in preparing HEC-FIA models of the Sacramento and San Joaquin basins as part of their Phase I Comprehensive Study of the two basins.

CEWRC-IWR, Institute for Water Resources: Marshall and Swift Contract Review
CECW, Headquarters: Residual Risk Assessment and Communication
CESPK, Sacramento District: Sacramento and San Joaquin Comprehensive Study HEC-FIA Modeling

Statistics

(\$151,000)

A major review of the Upper Mississippi River System flood frequency relationships is underway for the Rock Island District. An investigation of the appropriate flood frequency estimation methodology was performed by analyzing unregulated flow estimates for the major drainage areas. Recommendations from the analysis were reviewed by a Federal Interagency and Technical Advisory Group to the Corps of Engineers. Assistance to the Institute for Water Resources was provided by contracting research on the impact of climate change on the lake levels for Devils Lake, North Dakota. Other work regarding Devils Lake involved providing St. Paul district a review of the "five-box" model developed by the U.S. Geological Survey to forecast lake levels. Additionally, a review of the water quality predictions of the five box model were provided through a contractor. HEC reviewed the flood frequency computations and uncertainty estimates for Sacramento District's American River Study and Friant Dam.

CEMVR,	Rock Island District: Upper Mississippi Flood Frequency
CESPK,	Sacramento District: American River Flood Frequency, Friant Dam Regulated Frequency Curve
CEWRC-IWR,	Institute for Water Resources: Devils Lake
CEMVP,	St. Paul District: Devils Lake

Software Development Assistance

(\$129,800)

Software development enhancements were added to the HEC-RAS model during FY 1998. They included funding by the CECRL to add ice routines to the program and a utility program to model floating ice and perform ice stability analyses. These options are included in Version 2.2 of HEC-RAS. A new utility program was written to convert HEC-RAS terrain data into an HEC-UNET CSECT input data file. HEC also assisted the University of California, Davis, in its comprehensive CalFed Study by adding several enhancements to HEC-PRM reservoir system optimization model. They included: the capability to review the marginal costs as an output, the ability to better represent the evaporation function with several linear segments instead of one, and the capability to use a quadratic or nonlinear penalty functions in the analysis.

CESPK,	Sacramento District: HEC-RAS Utility
UCD,	University of California, Davis: Enhancements to HEC-PRM for CalFed Study
MWD,	Metropolitan Water District-Southern California: HEC-DSS GUI Improvements

Acknowledgments

The following consultants contributed to accomplishment of HEC work during FY 1998.

Robert Barkau

Private Consultant and developer of the UNET software has provided development and support to adapt UNET to perform unsteady flow modeling in HEC-RAS.

Colorado State University

Provided an independent technical review of the U.S. Geological Survey's "five box model" application to forecasting water quality impacts from Devil's Lake outflows. Principal staff was Dr. Darrel G. Fontane.

David Ford Consultants

Performed a series of assistance projects covering reservoir system optimization for flood control, development of an event parameter optimization routine and Technical Reference Manual for HEC-HMS, and flood damage reduction using risk-based analysis. Dr. David Ford was the principal staff person.

Dodson and Associates, Inc.

Houston, TX., assisted in the preparation of the draft applications guide for the HEC-FDA computer program. Principal staff was Roy Dodson.

Paul Ely

Private consultant, software design and development for HEC-HMS hydrologic processes simulation.

Wayne Haythorn

Private Consultant, provided assistance in development of HEC-FDA Version 1.0. He redesigned and coded the database structure and operations associated with the program.

Ken Kirby

Private consultant, assisted in the application of the HEC-PRM to the Central and South Florida Water allocation study.

Klinefelter, Inc.

Private consultants, provided assistance in the analysis of the Tooele Groundwater Flow Model Study.

Thomas Lin

Private contractor, aided in the development and application of the Tooele Groundwater model.

Steven Piper

Private Consultant, has developed the majority of the computational code (SNET) for the HEC-RAS package.

Resource Management Associates

Assisted HEC in development of a series of computer programs and routines associated with the Water Control Data System (WCDS). These included extensive design and coding of the HEC-HMS, HEC-RSS, HEC-RAS WCDS interface, HEC-FIA, and the Control and Visualization Interface. They also assisted in development of the HEC-FDA program. Principal staff was Dr. John DeGeorge.

University of California, Davis

Provided a general oversight in technical assistance in the development and application of reservoir system optimization models. Principal staff was Dr. Jay Lund. Provided technical assistance in statistical methods for estimating missing data. Principal staff was Robert Shumway.

University of Texas

Provided assistance in development of links and GIS applications for use in the HEC-HMS program. Also provided routines for use in HEC Reservoir System Optimization models. Principal staff persons were Dr. David Maidment and Dr. Paul Jensen, Francisco Olivera, Seth Ahrens, Seann Reed and Ben Bigelow.

US Geological Survey

Provided technical assistance for interfacing HEC-HMS with MODFLOW for groundwater surface water interaction. Principal staff was David Prudic.

Utah State University

Provided an analysis of potential impacts of climate change on future Devil's Lake levels. Conducted a seminar on risk-based evaluations for dam safety. Principal staff persons were Dr. Upmanu Lall and Dr. David Bowles, respectively.

Mr. R. G. Willey

Private contractor, Davis, California, provided a review of the U.S. Geological Survey's "five box model" application to forecasting water quality impacts from Devils Lake's outflows.

FY 1998 Annual Report
Hydrologic Engineering Center

Listed below are the other than full time staff that contributed to the accomplishments during FY 1998.

NAME	TYPE OF POSITION	DIVISION	TITLE
Cameron T. Ackerman	UCD Intern	Training	Civil Engineer
Ann M. Belara	Student Hire	Training	Office Automation Clerk
Todd H. Bennett	Student Hire	Research	Civil Engineer
Judy H. Cheng	Student Hire	Planning Analysis	Office Automation Clerk
Fulgene D. Cortez	Student Hire	Executive	Office Automation Clerk
Crystal R. DeCastro	Student Hire	Planning Analysis	Civil Engineer
Jason M. Dorcy	Student Hire	Technical Assistance	Computer Clerk
Mark R. Jensen	UCD COOP	Training	Civil Engineer
Bryton S. Johnson	UCD Intern	Research	Civil Engineer
Dustin J. Jones	UCD Intern	Planning Analysis	Civil Engineer
Andreas F. Krause	UCD Intern	Research	Civil Engineer
King H. Lam	Student Hire	Technical Assistance	Computer Clerk
Raymond H. Lee	Student Hire	Technical Assistance	Computer Clerk
Tom C. Lin	Student Hire	Research	Civil Engineer
Scott M. McClusky	Student Hire	Technical Assistance	Computer Clerk
Jason T. Needham	UCD Intern	Planning Analysis	Civil Engineer
Jonathan F. Peters	Student Hire	Technical Assistance	Computer Clerk
Eric L. Peterson	Student Hire	Technical Assistance	Computer Clerk
Jaime K. Ridler	Student Hire	Technical Assistance	Computer Clerk
William A. Scharffenberg IV	UCD COOP	Technical Assistance	Civil Engineer
Tina T. Tu	Student Hire	Technical Assistance	Office Automation Clerk
Matt F. Wilson	Student Hire	Research	Computer Clerk



FRONT ROW

David Goldman, Jeff Houghten, Scott McCluskey, James Doan,
Darryl Davis, Marilyn Hurst, Doug Foster, Penni Baker, Joan Klipsch

BACK ROW

Al Montalvo, Dan Barcellos, Josie Garcia-Moreno, Bob Carl, Fulgene Cortez, Art Pabst, Tina Tu, Harry Dotson,
Diane Cuming, Arlen Feldman, Adela Pucci, Mike Burnham, Mark Lue, Tom Evans, Dave Watkins, Mark Jensen,
Cameron Ackerman, Richard Hayes, Lisa Pray, Bill Scharffenberg, Mike Gee, Bill Johnson, Bill Charley, Steven Piper,
Gary Brunner, Andreas Krause, Carl Franke